Integrated Optimization of Hybrid Energy Networks

GroeneWarmte Software Chain

GroeneWarmte

3D green heat system integrator

GroeneWarmte

Contents

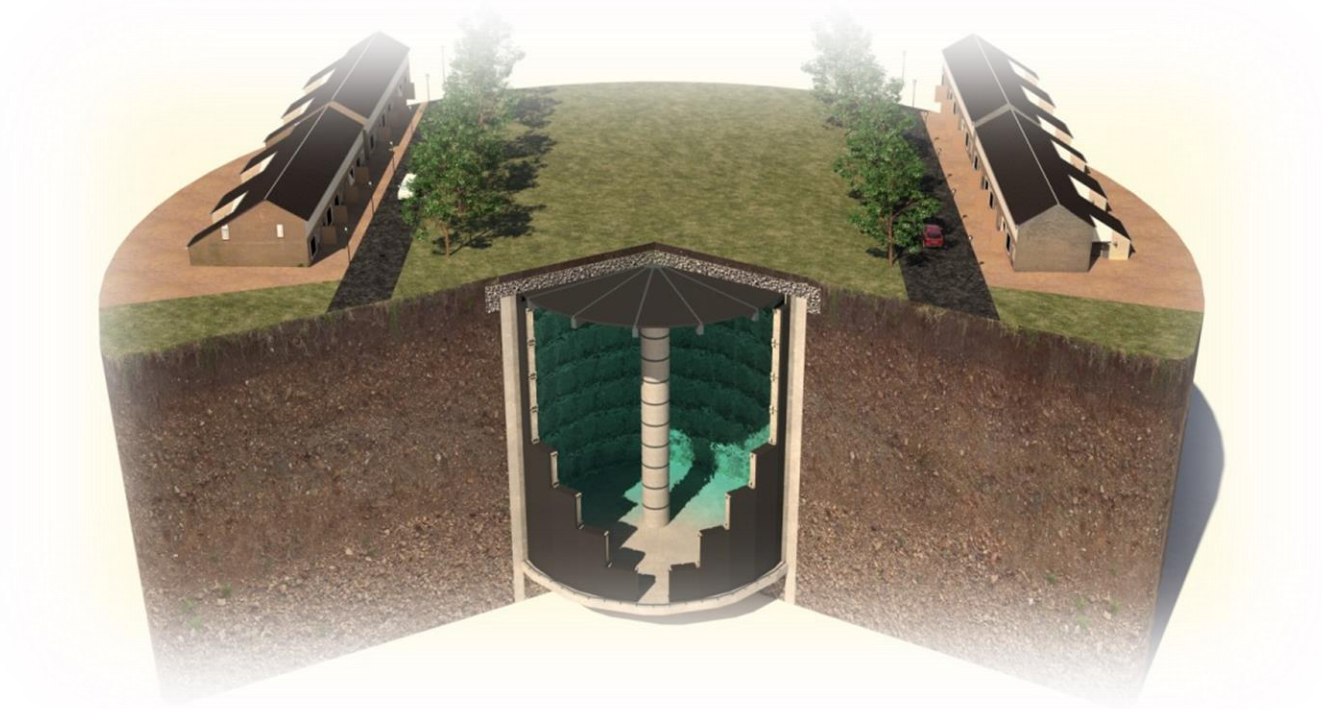
- GroeneWarmte (GreenHeat)
- Software Chain
- Optimization of Energy Networks

GroeneWarmte

Introduction - Repositioning

ecovat®

Known for its storage solutions.



GroeneWarmte

Introduction - Repositioning

ecovat®

Known for its storage solutions.

GroeneWarmte

3D green heat system integrator

Unbiased towards specific technology.

GroeneWarmte

Introduction - GreenHeat

Activites

Advice | Develop

Domains

Hardware | Software

GroeneWarmte

3D green heat system integrator

Unbiased towards specific technology.

GroeneWarmte

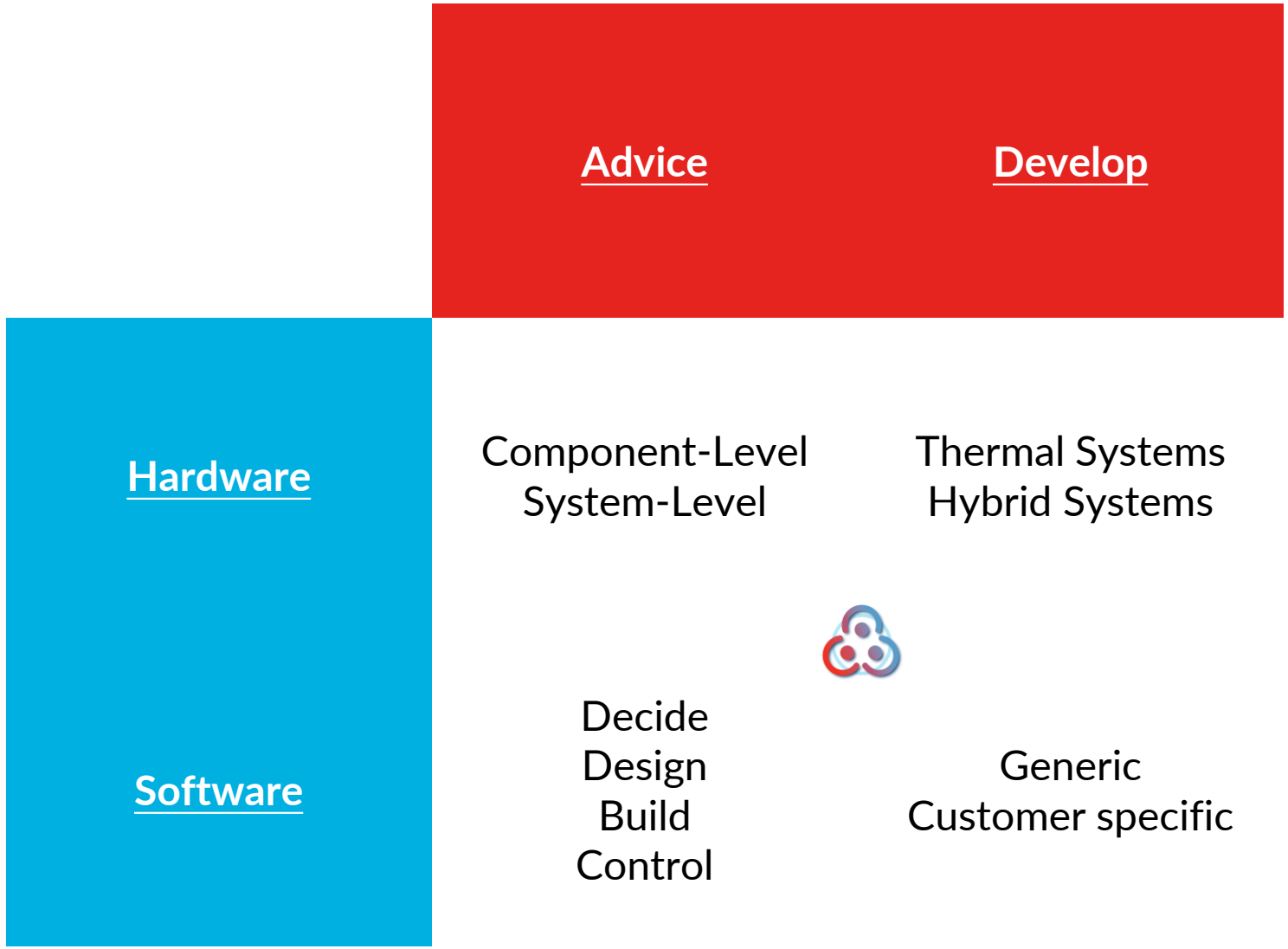
Introduction - GreenHeat

Activites

Advice | Develop

Domains

Hardware | Software



GroeneWarmte

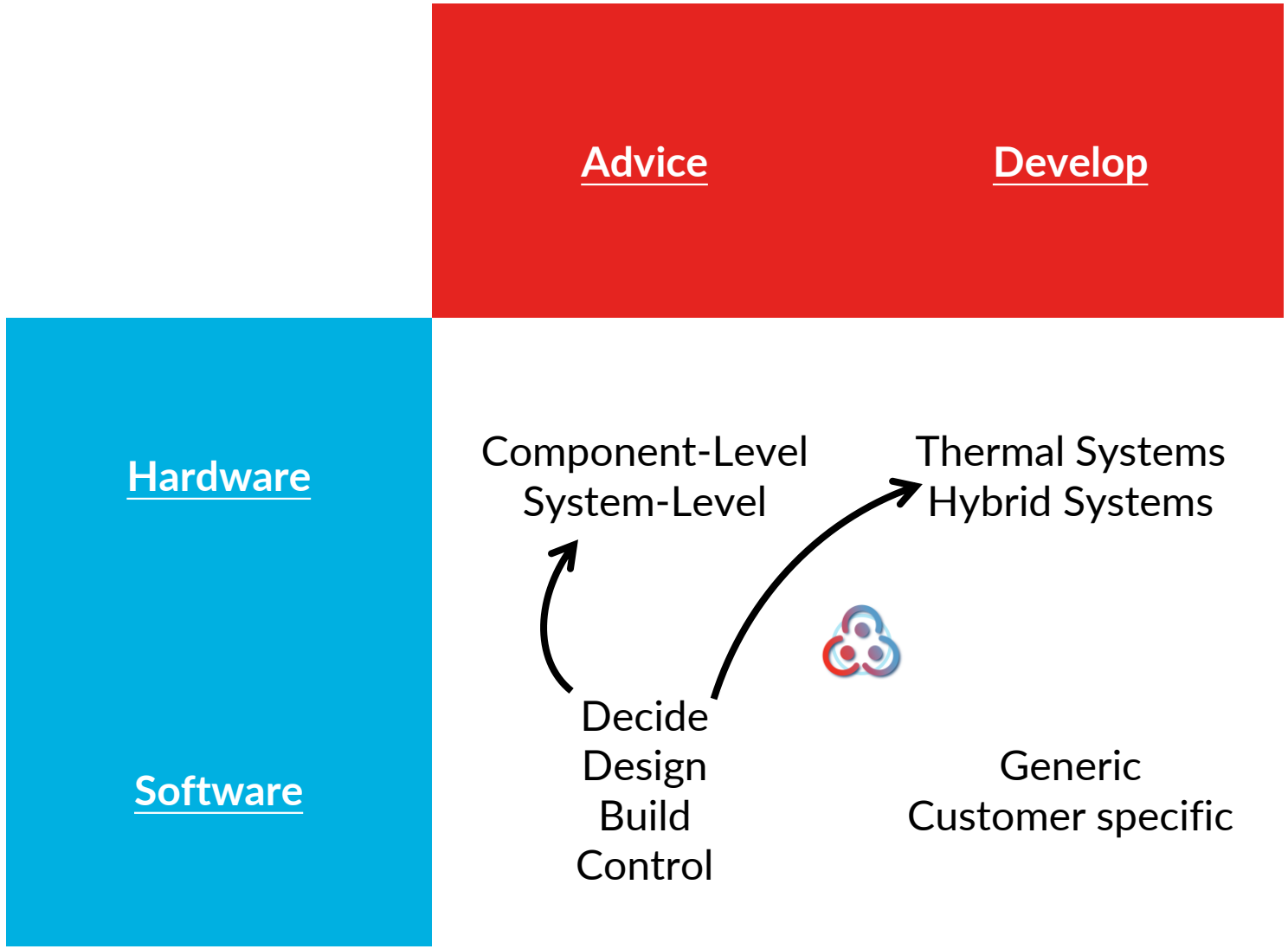
Introduction - GreenHeat

Activites

Advice | Develop

Domains

Hardware | Software



Introduction - Software

Integrated Optimization of Hybrid Energy Networks

GroeneWarmte

Introduction - Software

| Decide | Design | Build | Control |

| Hybrid Systems |

Advice **Develop**

Hardware

Software

Component-Level
System-Level

Thermal Systems
Hybrid Systems

Decide
Design
Build
Control

Generic
Customer specific

GroeneWarmte

Introduction – About Me

Wiet Mazairac

R&D Engineer @ Ecovat
Head of Digital @ GreenHeat

Mainly working on the development of software

GroeneWarmte

Software - Overview

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

GroeneWarmte

Software - Overview

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

| Decide **| Design |** Build | Control |

System Optimizer

Underground Optimizer

GroeneWarmte

Software - Overview

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

| Decide **| Design |** Build | Control |

System Optimizer

Underground Optimizer

| Decide | Design **| Build |** Control |

Underground Visualizer

GroeneWarmte

Software - Overview

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

| Decide **| Design |** Build | Control |

System Optimizer

Underground Optimizer

| Decide | Design **| Build |** Control |

Underground Visualizer

| Decide | Design | Build **| Control |**

System Control

Control Optimizer

GroeneWarmte

Software - Decide

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

- Determines project feasibility
- Based on open en proprietary data
- Automated for neighborhoods and districts
- Generates report

- To quickly inform stakeholders

GroeneWarmte

Software - Decide

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

- Determines energy demand and supply for neighborhoods and districts
- Compares properties of unknown areas with properties of known areas

- To provide an overview of the current situation
- To generate data for the design phase

GroeneWarmte

Software - Decide

| Decide | Design | Build | Control |

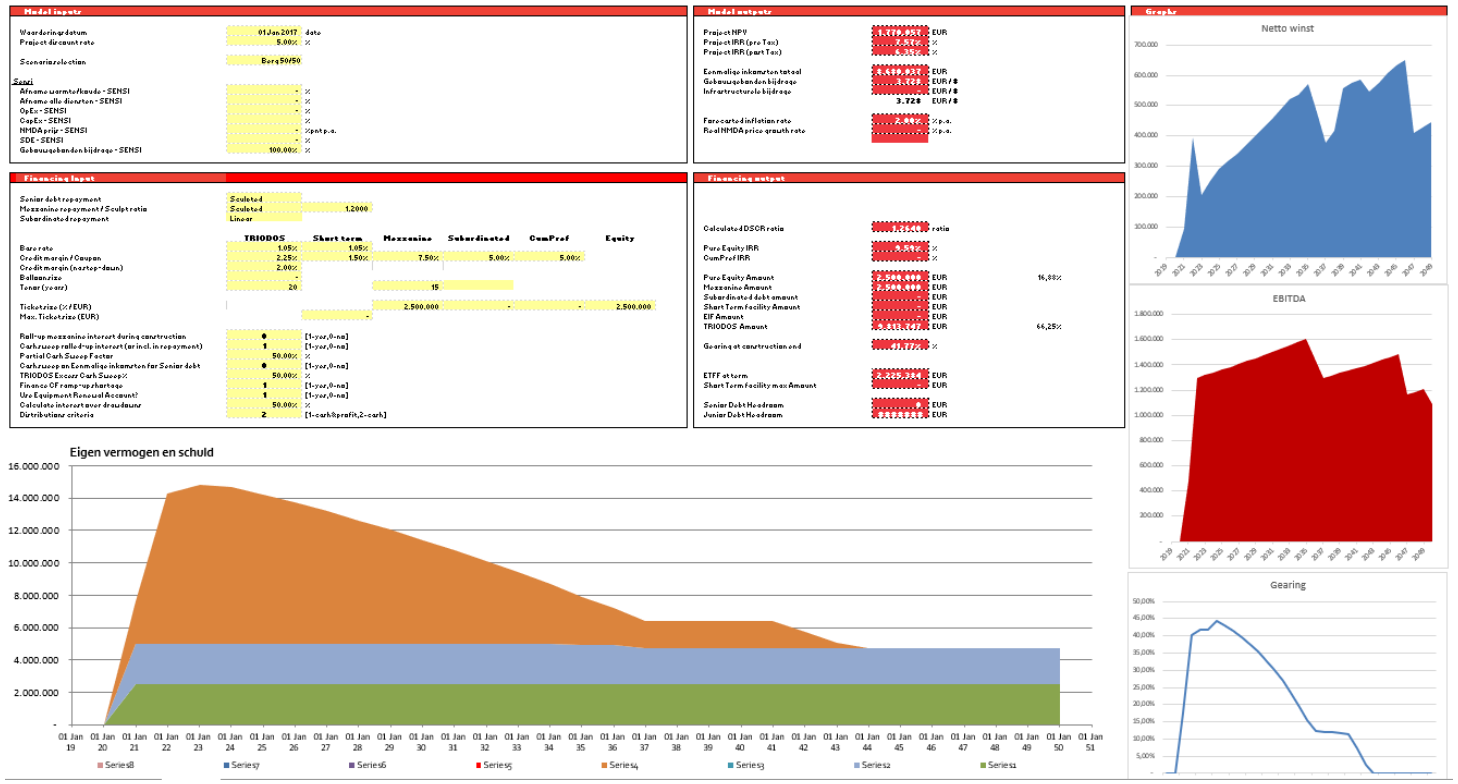
Quick Scanner

Energy Forecaster

Investment Modeler

- Determines OpEx and Capex
- Determines financial feasibility
- Automated for neighborhoods and districts

- To inform investors
- To select feasible projects



GroeneWarmte

Software - Overview

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

| Decide **| Design |** Build | Control |

System Optimizer

Underground Optimizer

| Decide | Design **| Build |** Control |

Underground Visualizer

| Decide | Design | Build **| Control |**

System Control

Control Optimizer

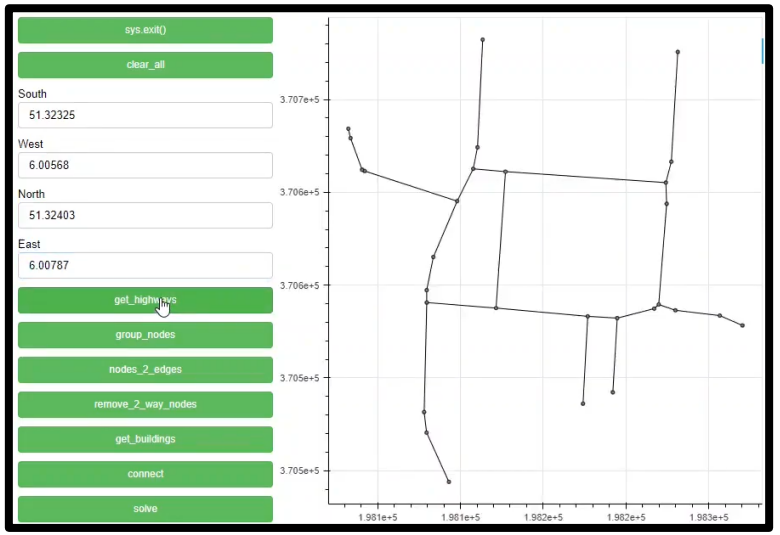
GroeneWarmte

Software - Design

| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer



Single Carrier District Heating

- Determines optimal topology and capacity
- Retrieves street pattern

GroeneWarmte

Software - Design

| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Simplifies street pattern
- Retrieves building data

Single Carrier District Heating

GroeneWarmte

Software - Design

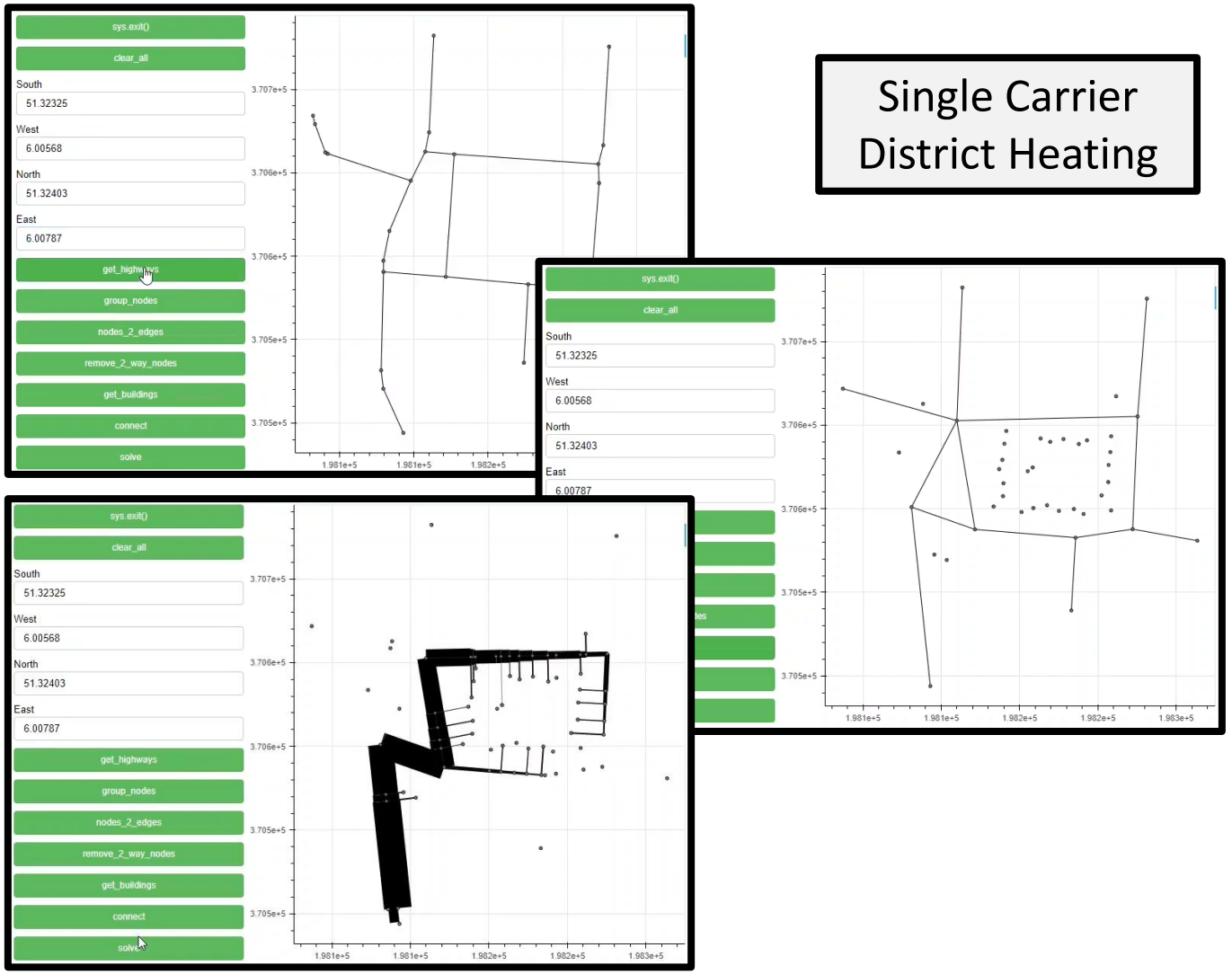
| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Determines optimal location and capacity of pipes

- MILP
- Pipe diameter not continuous
- Solver selects diameter from set determined by pipe supplier



Single Carrier District Heating

GroeneWarmte

Software - Design

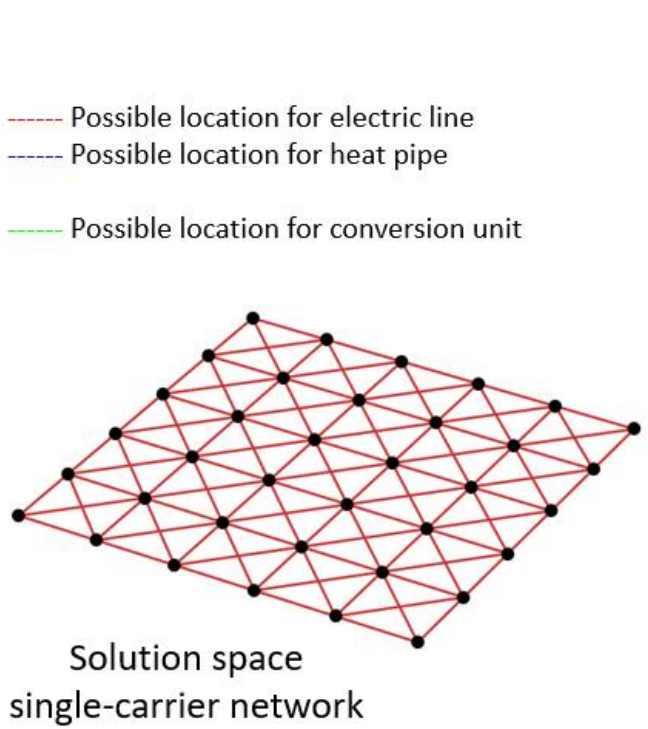
| Decide | **Design** | Build | Control |

System Optimizer

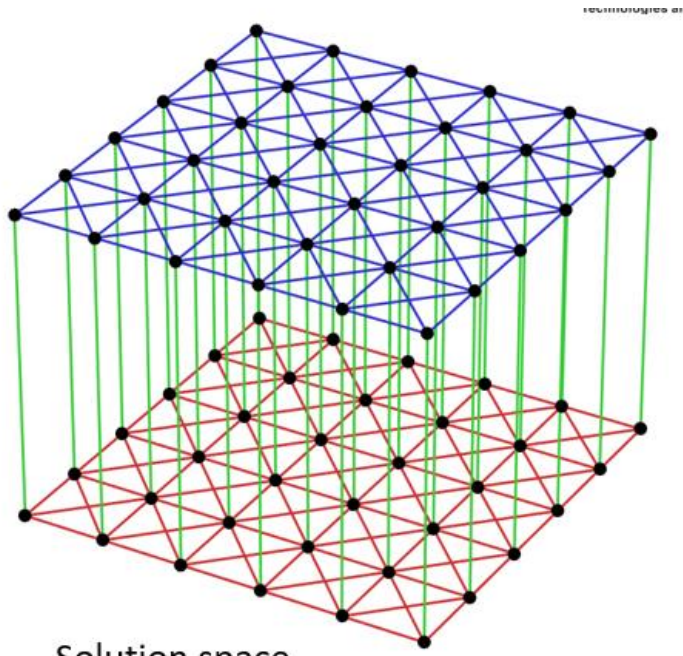
Underground Optimizer

Multi Carrier

- Same concept: MILP
- Variables added:
  - Additional carriers
  - Conversion
  - Storage



Solution space
single-carrier network



Solution space
multi-carrier network

GroeneWarmte

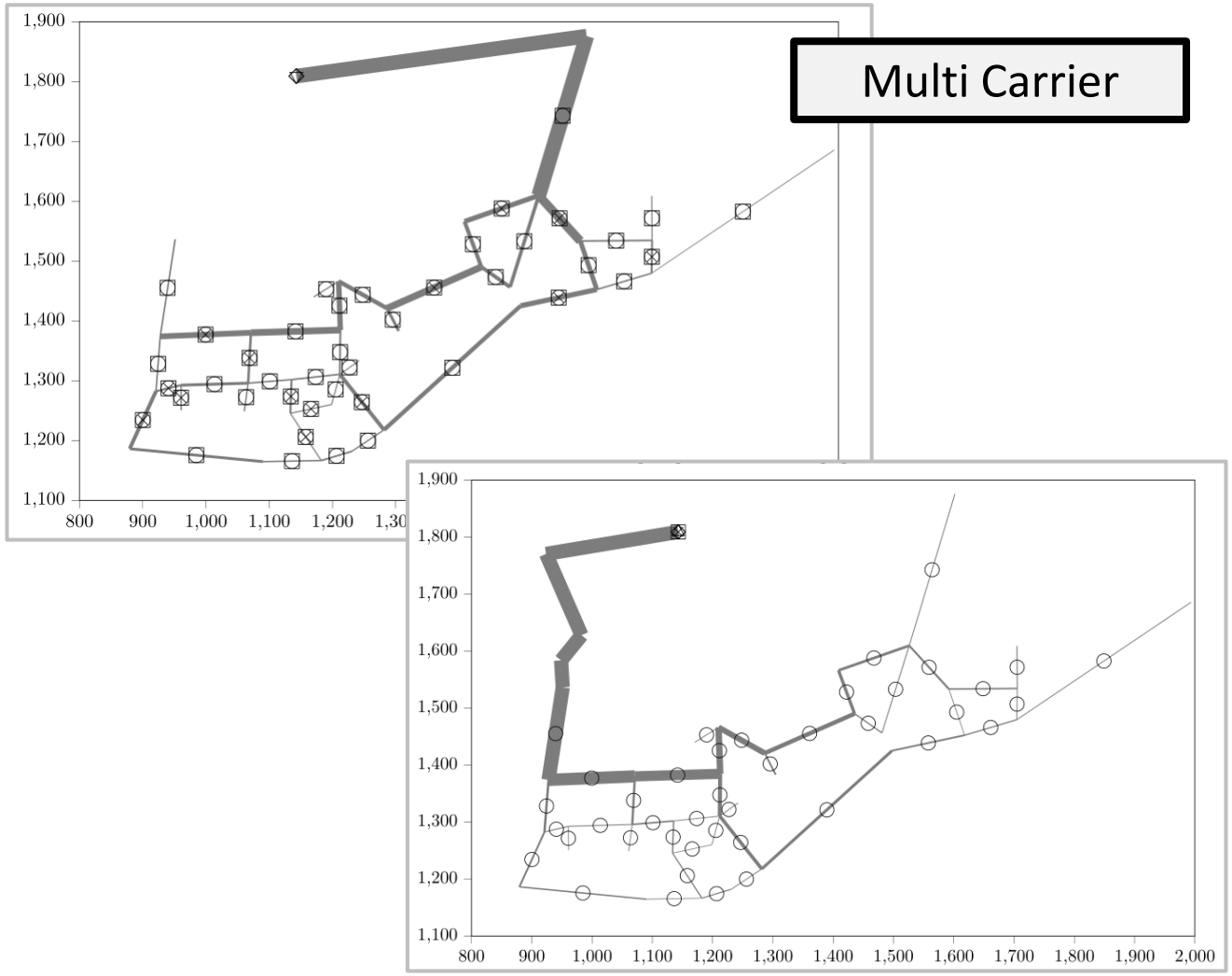
Software - Design

| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Topology



GroeneWarmte

Software - Design

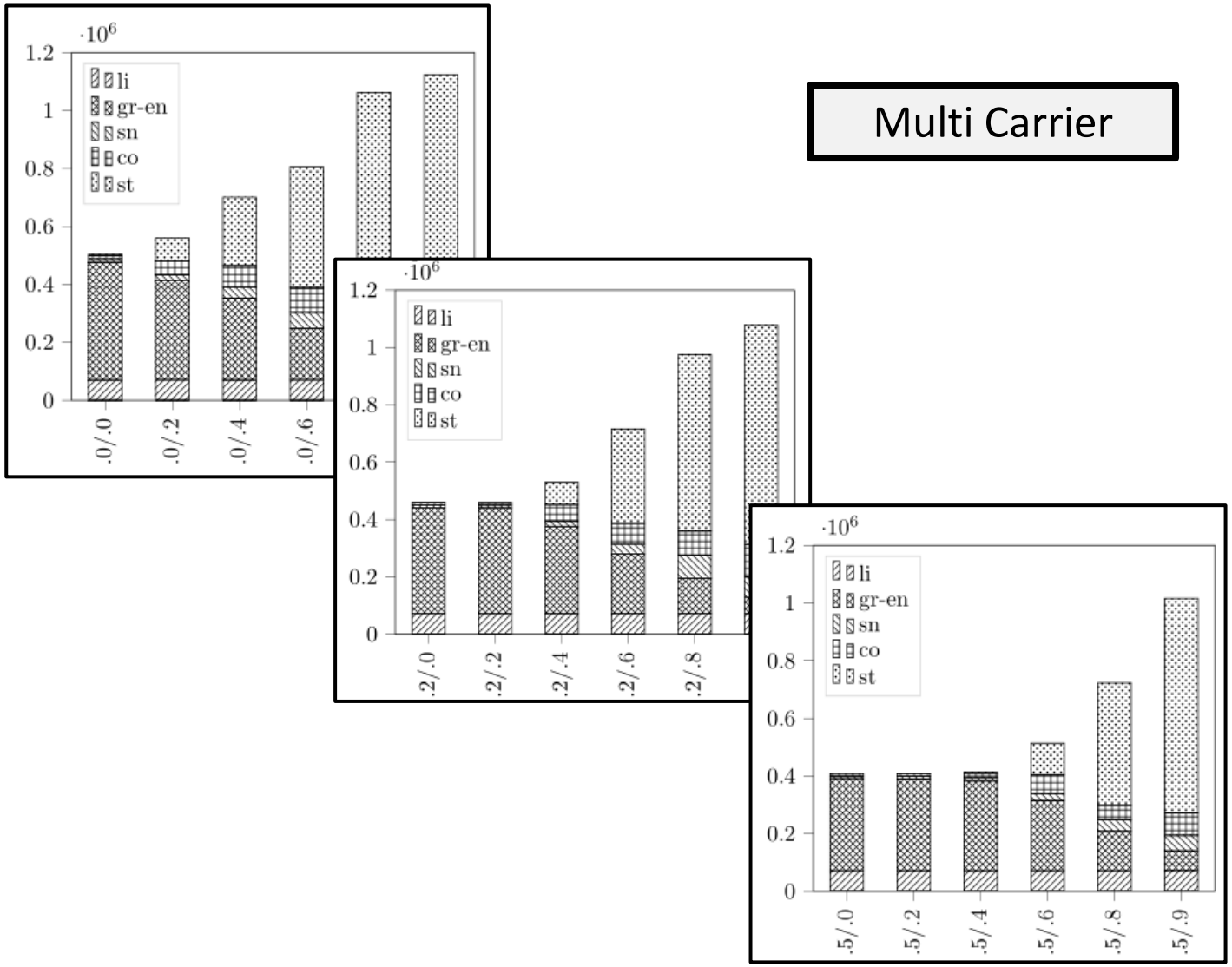
| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

Multi Carrier

- Costs for different scenarios



GroeneWarmte

Software - Design

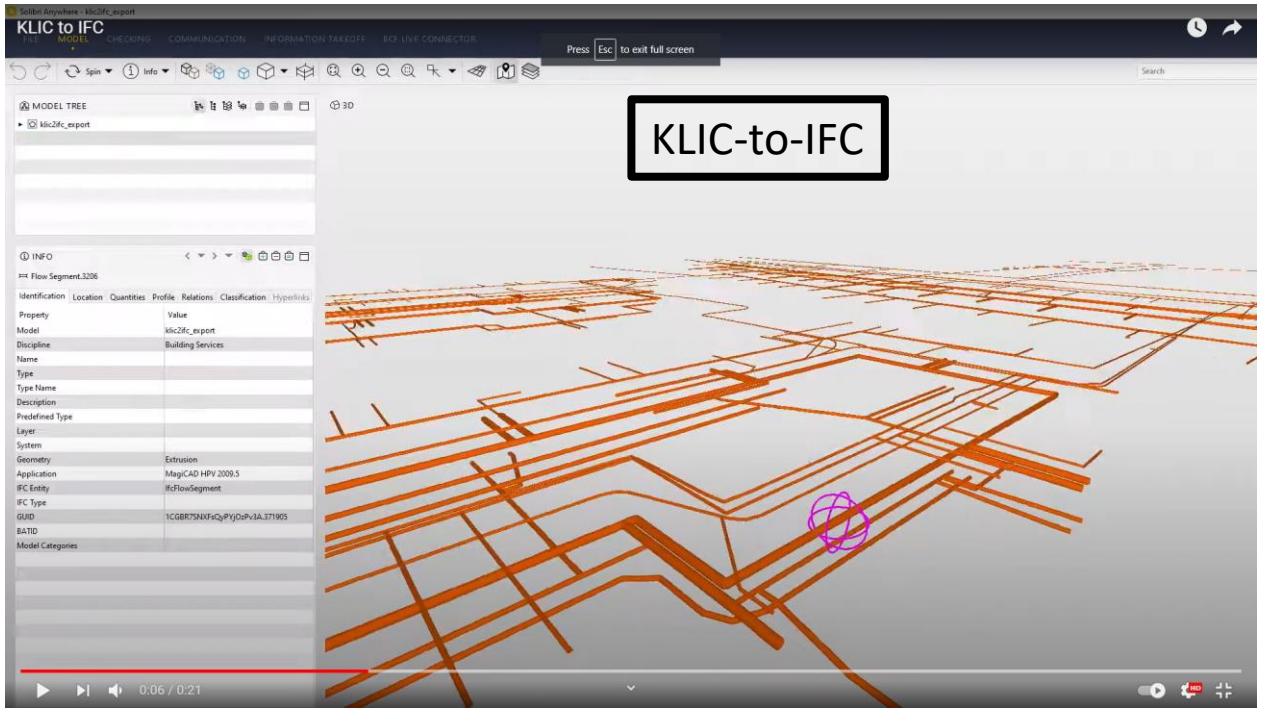
| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Determines optimal path of pipes and lines
- Avoids obstacles
  - e.g. trees
  - existing infrastructure

- To reduce unexpected costs



GroeneWarmte

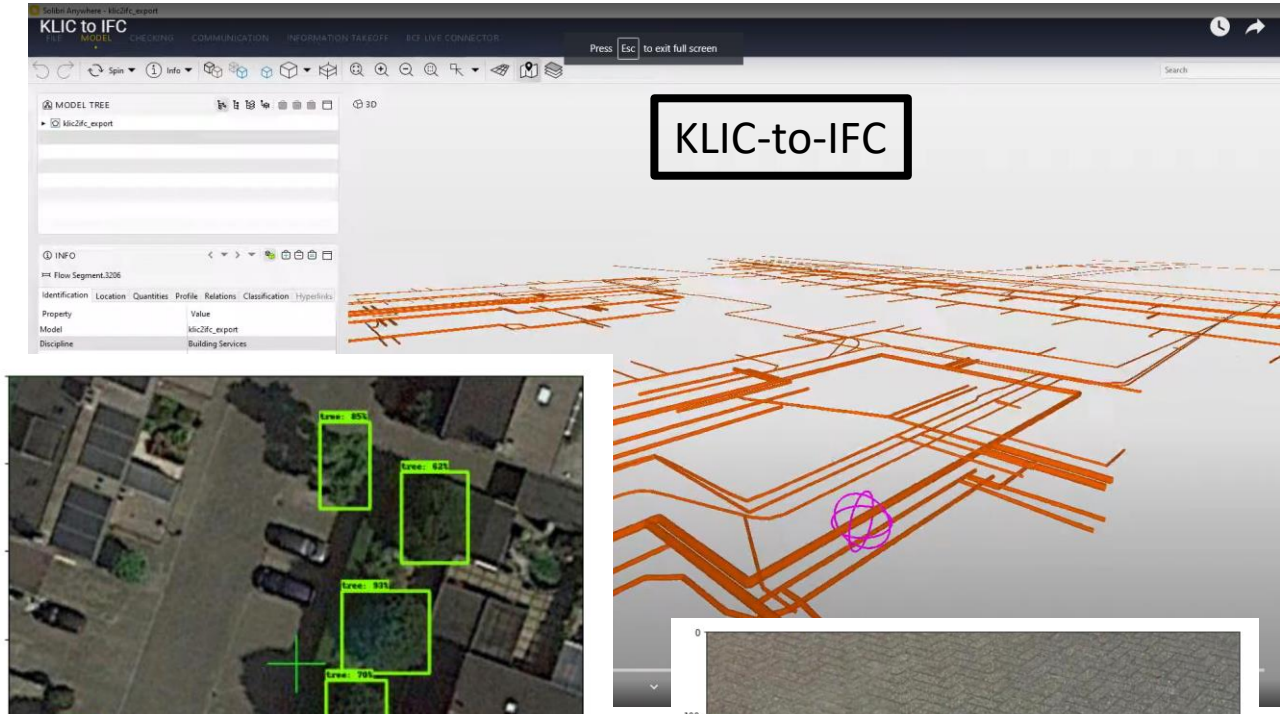
Software - Design

| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Determine location of obstacles
  - Existing maps
  - Image recognition



GroeneWarmte

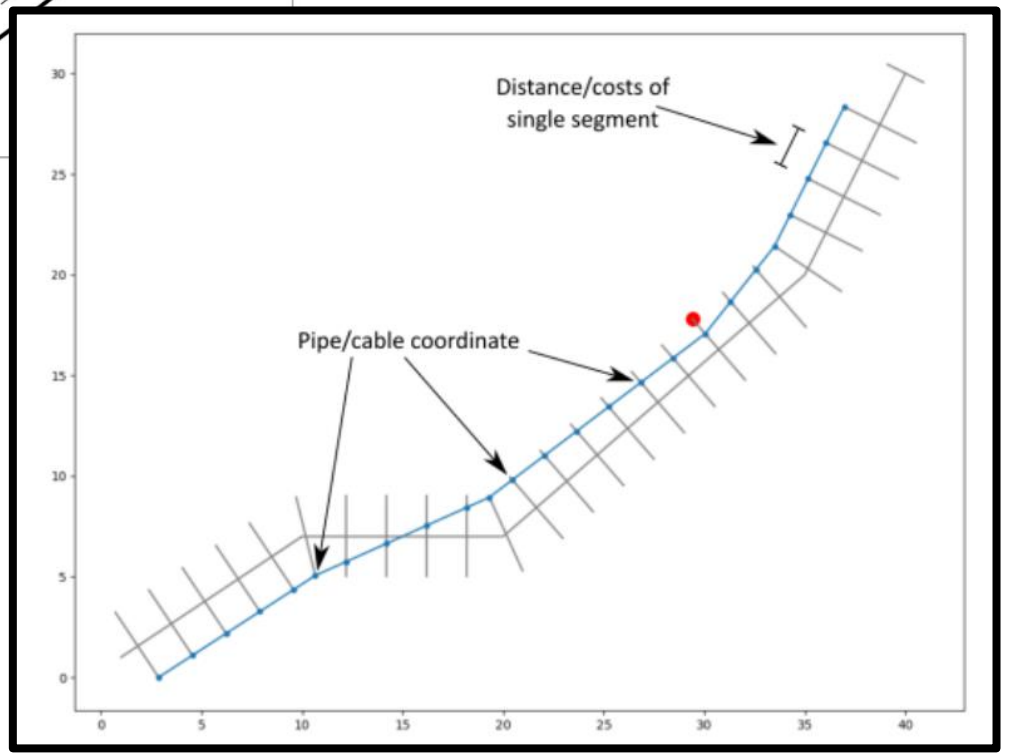
Software - Design

| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Determine optimal path
  - Avoiding obstacles



GroeneWarmte

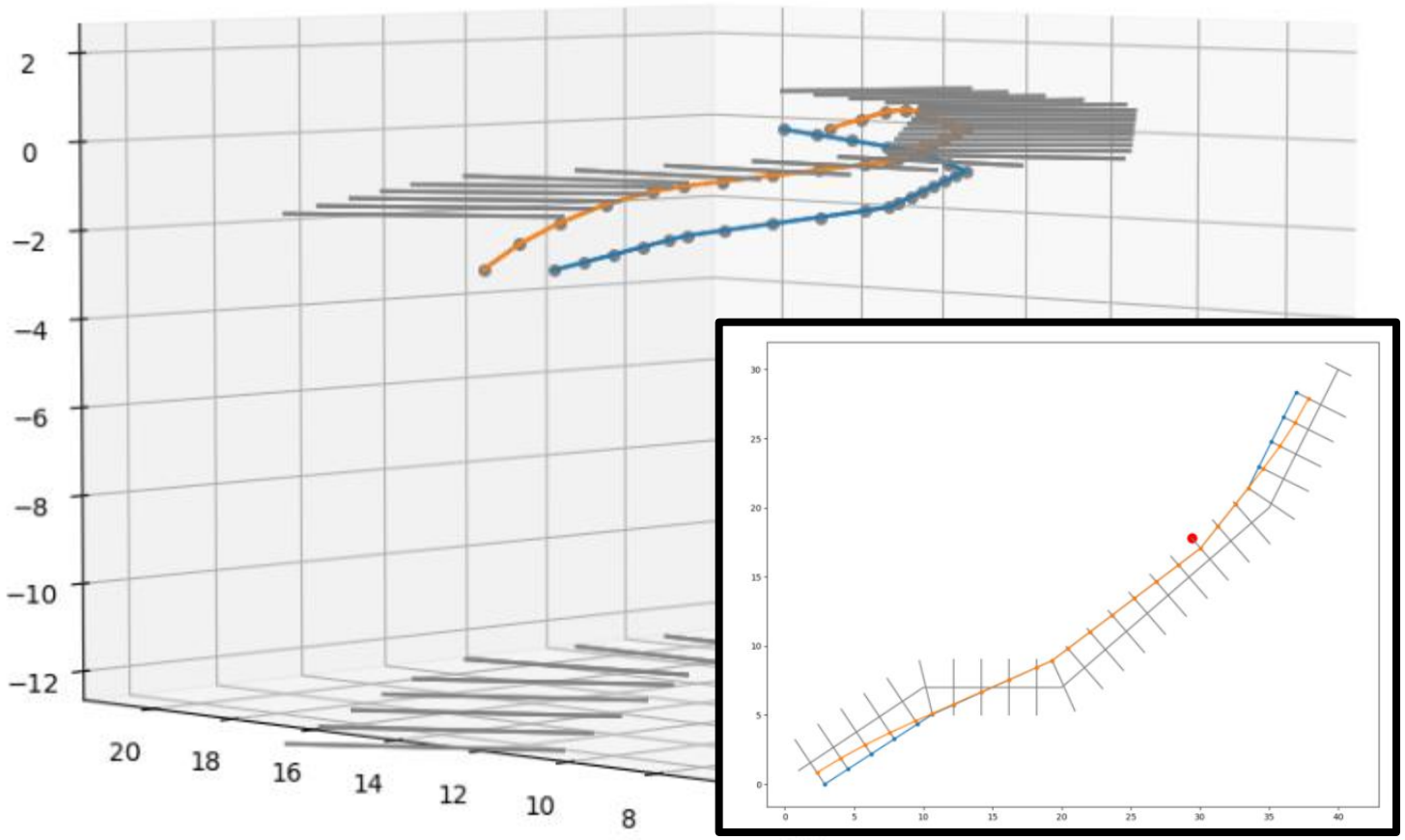
Software - Design

| Decide | **Design** | Build | Control |

System Optimizer

Underground Optimizer

- Determine optimal path
  - Avoiding obstacles
  - Avoiding existing infrastructure



GroeneWarmte

Software - Overview

| Decide | Design | Build | Control |

Quick Scanner

Energy Forecaster

Investment Modeler

| Decide **| Design |** Build | Control |

System Optimizer

Underground Optimizer

| Decide | Design **| Build |** Control |

Underground Visualizer

| Decide | Design | Build **| Control |**

System Control

Control Optimizer

GroeneWarmte

Software - Control

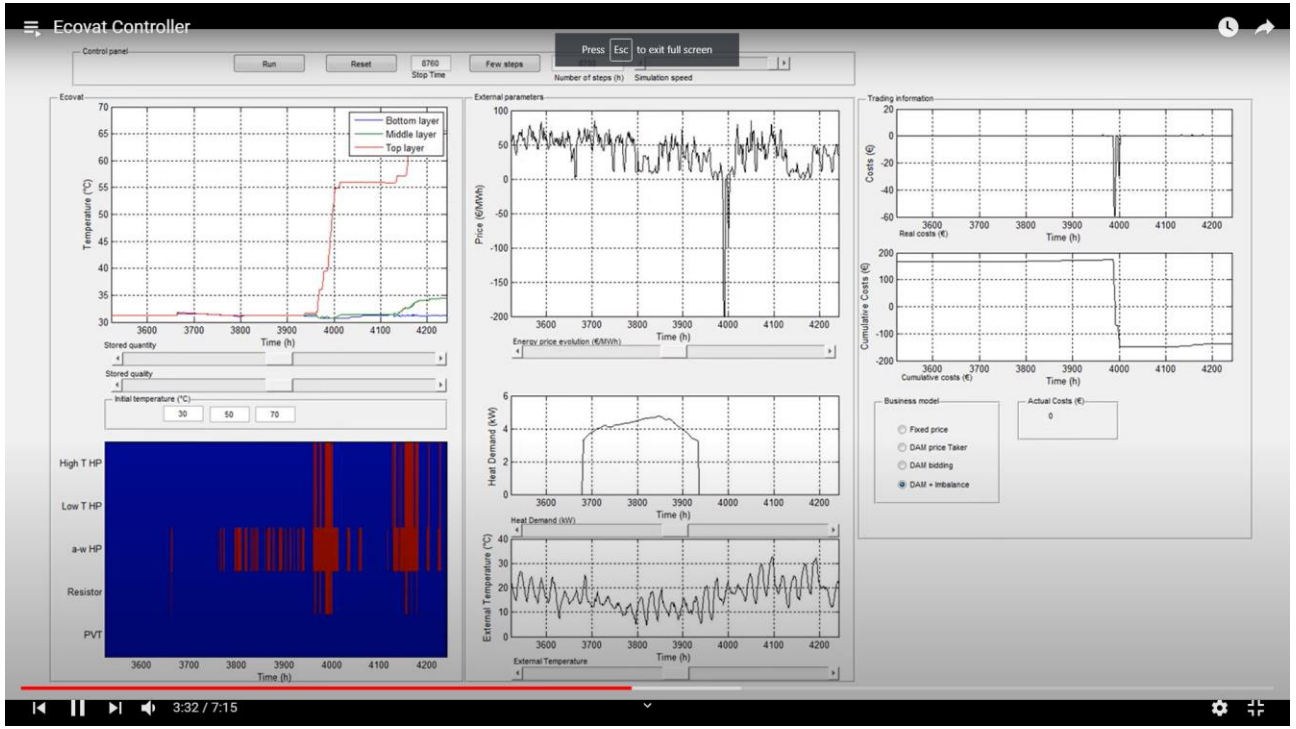
| Decide | Design | Build **| Control |**

System Control

Control Optimizer

- Determines control strategy
- Based on demand, energy costs and state of charge

- To minimize operational costs



GroeneWarmte

Software - Control

| Decide | Design | Build **| Control |**

System Control

Control Optimizer

- Various models
- Differ in accuracy and speed

Methode	Model beperking	Discrete variabele	Stoch. variabele	updates	optimaal	Complexe problemen	Off-line berekening	Off-line rekentijd	On-line rekentijd
DP	++	++	++	-	+	?	+	10 d	1 sec
MILP	+	++	-	+	+	-	-	0	1 h
MPC	+	-	-	+	-	-	-	0	1 m
RL	++	++	++	-	-	-	+	10 d	1 sec
ADMM	-	-	+	+	+	+	-	1h	1 sec

GroeneWarmte

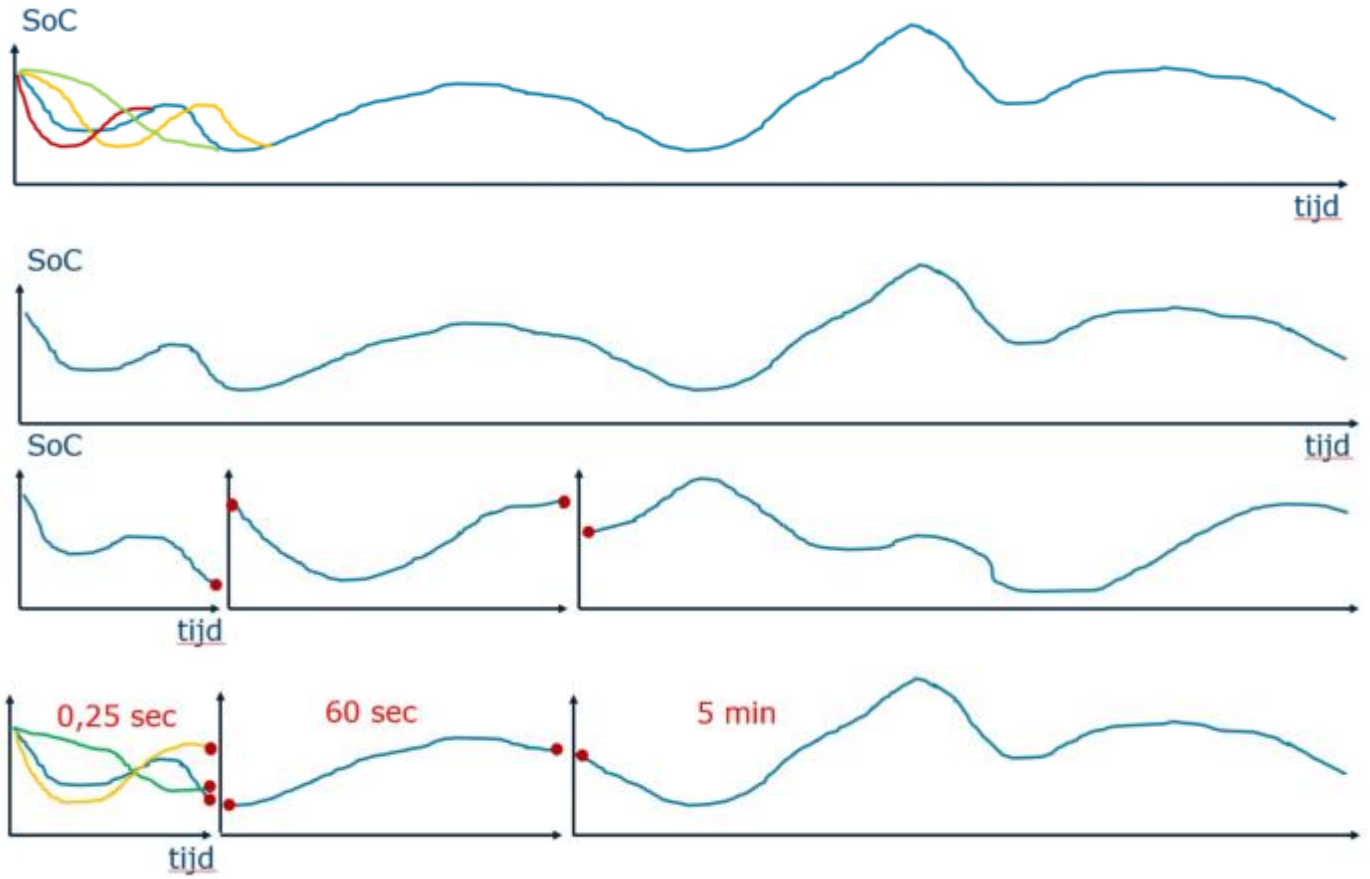
Software - Control

| Decide | Design | Build **| Control |**

System Control

Control Optimizer

- Alternating Direction Method of Multipliers (ADMM)
- To reduce calculation costs/time



GroeneWarmte

Outlook

- Various stages of development
- 6 months from now: first products available
- 12 months from now: most products available

- Acquisition of funding
  - MOOI funding
  - by the Netherlands Enterprise Agency
  - cooperate with industrial and academic partners

GroeneWarmte

Conclusion/Summary

- GroeneWarmte develops a chain of tools for:
  - Decision
  - Design
  - Build
  - Control

- Some products are (nearly) finished
- Some products are still under development

Contact

GroeneWarmte

3D green heat system integrator

www.groenewarmte.com

wiet.mazairac@groenewarmte.com